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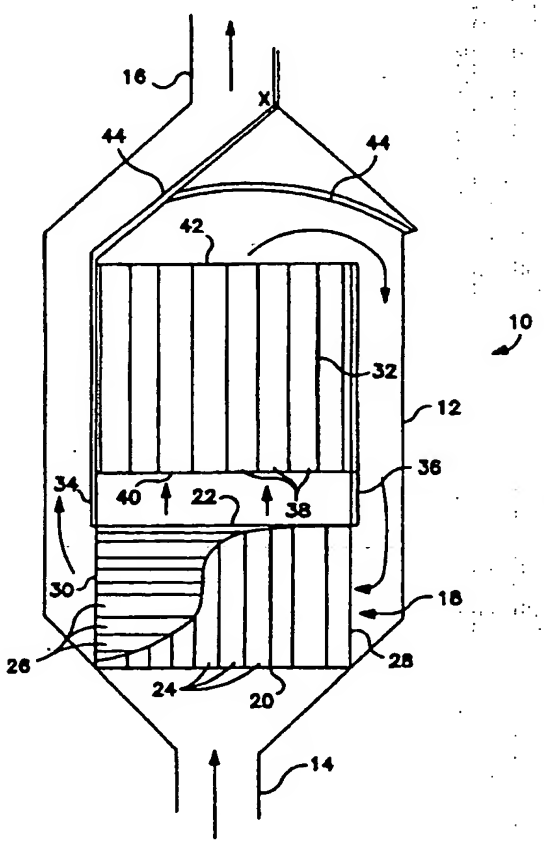
(54) Title: DESIGNS FOR PACKAGING A LOW HYDROCARBON EMISSION SYSTEM

(57) Abstract

An exhaust gas treatment device (10) defines a flow path through a preliminary catalyst zone, a hydrocarbon trap (32) and a secondary catalyst zone in a single canister (12). The two catalyst zones are disposed in heat exchange relation to each other within a single crossflow carrier (18) to improve the performance of the hydrocarbon trap (32) and to accelerate the rise of the catalytic material in second catalyst zone to its light-off temperature to improve its performance in converting hydrocarbons desorbed from the trap. In a particular embodiment, a device (110) according to the present invention can be configured to treat two independent exhaust gas streams simultaneously.



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DESIGNS FOR PACKAGING A LOW HYDROCARBON EMISSION SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to the reduction of noxious automotive emissions, and more particularly to an exhaust treatment apparatus comprising a heat exchanger to draw heat from the exhaust gas stream of an automotive engine to a catalyst material.

In order to meet Governmental emissions standards for internal combustion engine exhaust, motor vehicle manufacturers emplace catalytic converters in the exhaust gas lines of their vehicles. A common form of converter comprises a catalyst member which comprises a honeycomb carrier having gas flow passages extending therethrough. The carrier carries a coating of catalytically active material which is effective to convert noxious components of the exhaust gas, which may include unburned hydrocarbons, carbon monoxide and NO_x, to innocuous substances, e.g., to carbon dioxide, water and nitrogen, respectively. A common type of catalyst is a three-way catalyst, which typically comprises catalytically effective amounts of platinum group metals dispersed on one or more refractory inorganic oxide support materials such as various aluminas, cerias and zirconias. Three-way catalysts are known for their ability to substantially simultaneously oxidize unburned hydrocarbons and carbon monoxide to CO_2 and H_2O while reducing NO_x to nitrogen. U.S. Patent 4,171,287 to Keith, dated October 16, 1979, and U.S. 4,678,770 to Wan et al, dated July 7, 1989 disclose several three-way catalyst compositions and methods of preparing them, and both are hereby incorporated herein by reference. Oxidation catalysts may be prepared in the same manner, without the inclusion of a rhodium component.

Generally speaking, in preparing a platinum group metal catalyst, various compounds and/or complexes as well as elemental dispersions of platinum group metals may be used to achieve deposition of the metal on the support particles. Water soluble compounds or complexes such as amine solubilized platinum and/or palladium hydroxides, as well as organic soluble compounds or complexes, may be used. The only limitation on the liquids to deposit these compounds, complexes, or elemental dispersions is that the liquids should not react with the metal compound and must be capable of being removed from the catalyst by volatilization or decomposition by subsequent calcination and/or vacuum treatment. Whatever the type of metal compound used, during subsequent calcination, essentially all of the metal will be converted to the catalytically active form. The platinum group metals are sometimes supplemented with one or more base metals of Group VII and metals of Group VB and/or VIB of the Periodic Table of Elements, e.g., one or more of chromium, copper, vanadium, cobalt, nickel and iron may thus be employed. Optionally, catalytically active base metals may be used in oxidation catalysts to the exclusion of platinum group metals.

Oxidation catalysts and three-way catalysts are generally not effective until they have been heated to a threshold temperature often identified as the "light-off" temperature. Ordinarily, during the operation of an automotive engine, the exhaust gases heat the catalytic converter to the light-off temperature within a few minutes of operation. However, during those initial minutes of operation known as the "cold-start" period, the engine and the exhaust system apparatus are cold, so the exhaust gases are relatively cold and quickly transfer the heat they contain to heat the catalytic converter and other components of the exhaust system. During the cold-start period, the exhaust gases are rich in hydrocarbons, which pass through the cold catalytic converter substantially unaffected. Recently, efforts have been made to reduce cold-start emissions, including incorporating an adsorbent hy-

drocarbon trap in the exhaust gas line. Such traps allow the exhaust gases to flow in contact with an adsorbent material, e.g., a molecular sieve, which adsorbs and thus retains the hydrocarbons during the cold-start period. When the adsorbent is heated to its desorption temperature, it exhibits a net desorption of hydrocarbons. A catalyst member capable of oxidizing hydrocarbons, including desorbed hydrocarbons, is conventionally disposed downstream of the trap.

Related Art

In SAE Paper 930739, Hochmuth et al disclose in Figure 8 a number of exhaust configurations in which a hydrocarbon trap is disposed between catalyst zones defined by discrete catalytic converters or passes of a heat exchange cross-flow carrier having three-way catalyst material in both passes. The Paper teaches the addition of air into the exhaust gas stream to burn desorbed hydrocarbons, including the injection of air at a point downstream from the hydrocarbon trap to assist in the combustion of desorbed hydrocarbons in a catalyst zone further downstream from the trap.

U.S. Patent 5,303,547 to Mieville et al, dated April 19, 1994, discloses in Figure 4, a catalyst apparatus in which a dual flow carrier is disposed in a bed of adsorbent material sealed in a canister. The dual flow carrier comprises uncatalyzed heat exchange ducts (72) and catalyst-coated ducts (74). Exhaust gas flows into the heat exchange ducts, and exits the carrier flowing into the surrounding adsorbent material, and then re-enters the carrier via the catalyst-coated ducts (74). In Figure 7, the patent shows a catalyst apparatus comprising a catalyst honeycomb catalyst member (122) comprising two pluralities of gas flow passages (124, 124') which communicate with two pluralities of passages (128, 128') in an adsorbent carrier (130). Exhaust gas enters the apparatus and is guided by an inlet manifold (118) into the first plurality of passages (124) in catalyst member (122), then

to the first plurality of passages (128) in adsorbent carrier (130). A bottom plate (138) forces the gas to return through adsorbent carrier (130) via passages (128') and then through passages (124') of catalyst member (122). Inlet manifold (118) then guides the exhaust gas out of the apparatus. The passages of pluralities (124, 124') run parallel to each other, as do the passages of pluralities (128, 128'), so the catalyst member (122) and the adsorbent carrier (130) are referred to herein as "counter-flow" devices to distinguish them from devices in which different pluralities of passages are disposed crosswise to each other.

U.S. Patent 3,929,418 to Wood, dated December 30, 1975, discloses a crossflow catalyst carrier mounted in a canister, in which the carrier defines a first catalyst zone for the reduction of nitrogen oxides and a second catalyst zone for the oxidation of carbon monoxide and unburned hydrocarbons, and teaches the injection of air into the exhaust gas stream at a point between the catalyst zones, to assist in oxidation in the second catalyst zone. Similar arrangements are taught in U.S. 3,860,535 (see column 3, lines 24 through 42) and U.S. 3,929,419 (see column 3, lines 51 through 63).

U.S. Patent 5,051,244 to Dunne et al, dated September 24, 1991 shows a valve-operated exhaust system in which, during the cold-start period of engine operation, exhaust gases are flowed through an adsorbent and then through a three-way catalyst. When the catalyst reaches its light-off temperature, the valves are used to bypass the adsorbent zone. A minor part of the hot exhaust gases is used to desorb hydrocarbons from the adsorbent and to flow them to the catalyst.

SUMMARY OF THE INVENTION

The present invention relates to an exhaust gas stream treatment device comprising a canister defining a canister interior and having a canister inlet for receiving an exhaust gas stream into the canister and a canister outlet

for discharging the exhaust gas stream from the canister. There is a heat exchange catalyst carrier in the canister having first and second inlet faces and first and second outlet faces, the inlet faces being distinct from the outlet faces. The catalyst carrier comprises first and second pluralities of gas flow passages defined by carrier walls on which are disposed respective catalytic materials. The first plurality of gas flow passages is open to and extends between the first inlet and outlet faces to define a preliminary catalyst zone, and the second plurality of gas flow passages is open to and extends between the second inlet and outlet faces to define a secondary catalyst zone. The first and second pluralities of gas flow passages are in heat exchange relation with each other. There is also a trap means disposed within the canister, the trap means having a trap inlet face and a trap outlet face and being permeable to gas flow therethrough from the trap inlet face to the trap outlet face. The trap means comprises a material having a hydrocarbon desorption temperature ("T_D") and is suitable for adsorbing hydrocarbons in the exhaust gas stream exiting the preliminary catalyst zone while the stream is below temperature T_D and for desorbing hydrocarbons while the stream is above temperature T_D. The catalyst carrier and the trap means are oriented with respect to each other, and the canister interior is dimensioned and configured, to define a flow path from the canister inlet to the first carrier inlet face, through the preliminary catalyst zone to the first carrier outlet face, then through the trap means and to the second carrier inlet face, through the secondary catalyst zone to the second carrier outlet face and then to the canister outlet. Optionally, the canister interior may be dimensioned and configured to provide a first gas flow conduit between the first carrier outlet face and the trap means inlet face, a second gas flow conduit between the trap means outlet face and the second carrier inlet face, and a gas flow discharge conduit connecting the second carrier outlet face with the canister

outlet.

In another aspect, the invention relates to a dual flow path exhaust treatment apparatus comprising a pair of heat exchange catalyst carriers. Each carrier comprises first and second pluralities of gas flow passages therethrough defined by carrier walls on which are disposed respective catalytic materials. The first plurality of passages in each carrier defines a preliminary catalyst zone and the second plurality of passages in each carrier defines a secondary catalyst zone. The preliminary catalyst zone of each carrier is in heat exchange relation with the secondary catalyst zone in the carrier and defines a separate gas flow path through the carrier relative to the secondary catalyst zone. There are conduit means for defining flow paths from the preliminary catalyst zone of each carrier to the secondary catalyst zone of the other carrier. There are also trap means as described above disposed in each flow path between the preliminary catalyst zone and the secondary catalyst zone.

In a particular embodiment, the conduit means comprise a canister defining a canister interior and having first and second canister inlets, each for receiving an exhaust gas stream. The canister may also comprise first and second canister outlets, for discharging the gas streams. The canister, the trap means and the carriers may be oriented with respect to each other, and the canister interior may be dimensioned and configured, to define two separate flow paths. Each flow path extends from a canister inlet to the first inlet face of one carrier, from the first outlet face of the carrier to the inlet face of a trap means, from the outlet face of the trap means to the second inlet face of the other carrier, and from the second outlet face of the second carrier to a canister outlet.

According to one aspect of the invention, any of the foregoing embodiments may comprise oxygen inlet means for allowing the injection of oxygen into the flow paths. The oxygen inlet means may be positioned at a point in a flow

path between the first outlet face of a carrier and a second inlet face of the same or a different carrier.

In any of the foregoing embodiments, at least one of the preliminary catalyst zones and the secondary catalyst zones may comprise a three-way catalyst material. As a separate feature, any catalyst carrier of a device according to the present invention may be dimensioned and configured so that exhaust gas flowing through the preliminary catalyst zone thereof flows in oblique relation to the exhaust gas flowing through the secondary catalyst zone.

The term "exhaust gas" as used herein and in the claims refers to the exhaust of hydrocarbon-fueled engines, including diesel engines, even though diesel exhaust includes non-gaseous components including solid carbon particulates and, depending on the temperature of the exhaust, may contain condensed oils.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is a schematic cross-sectional view of an exhaust gas treatment device in accordance with one embodiment of the present invention;

Figure 1B is a schematic cross-sectional view of a second embodiment of an exhaust gas treatment device in accordance with the present invention;

Figure 1C is a schematic plan view of the device of Figure 1B;

Figures 1D and 1E are views similar to that of Figure 1A of an exhaust gas treatment device in accordance with various alternative embodiments of the present invention;

Figure 2A is a schematic cross-sectional view of a dual gas stream treatment device in accordance with a particular embodiment of the present invention; and

Figure 2B is a schematic plan view of the device of Figure 2A.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS THEREOF

The present invention provides a combination catalytic converter and hydrocarbon trap apparatus for use in an exhaust gas treatment system. Unlike devices in the prior art, a device according to the present invention defines a flow path for exhaust gases in which there are two catalytic gas treatment zones with a hydrocarbon trap disposed between them, in a single canister.

One embodiment of an exhaust gas treatment device in accordance with the present invention is shown in Figure 1A. In this Figure, treatment device 10 comprises a canister 12 having a canister inlet 14 and a canister outlet 16. Inlet 14 defines a manifold that guides exhaust gases to a heat exchange catalyst carrier 18 mounted within canister 12.

Generally, a heat exchange catalyst carrier comprises channel walls that define first and second pluralities of gas flow passages through the carrier, thus providing first and second zones in the carrier. The first and second zones are disposed in mutual heat exchange relation, but the channel walls do not allow gas flow communication between the first and second zones. Typically, heat exchange carriers are constructed from metal, preferably corrosion-resistant metal such as stainless steel, or of a conventional ceramic material, e.g., cordierite, mullite, etc. The gas flow passages of the two zones in a carrier used in accordance with the present invention are disposed crosswise to one another; the carrier may therefore sometimes be referred to as a crossflow catalyst carrier, or as a crossflow carrier. Accordingly, carrier 18 has a first inlet face 20 and a first outlet face 22. A first plurality of parallel gas flow passages 24 extends through from first inlet face 20 to first outlet face 22. The carrier walls of gas flow passages 24 have a coating of catalytic material thereon effective to convert at least some of the noxious components of exhaust gas to innocuous substances, e.g., with an oxidation or a three-way cata-

lyst material, and thus define a preliminary catalyst zone. Carrier 18 further comprises a second plurality of fine, parallel gas flow passages 26 which extend from a second carrier inlet face 28 to second carrier outlet face 30. The carrier walls of gas flow passages 26 are coated with a catalytic material effective at least for the oxidation of hydrocarbons in the exhaust gas stream, and thus define a secondary catalyst zone in carrier 18. The respective gas flow paths of the preliminary and secondary catalyst zones are separate in that the gases flowing therethrough do not intermingle. A honeycomb-style carrier may have gas flow passages through each catalyst zone at a density of from about 100 to 600 cells per cross-sectional square inch. In alternate embodiments, a parallel plate-type heat exchange carrier may be employed instead of a honeycomb style member. A suitable plate-type carrier comprises a plurality of substantially parallel rectangular plates that are sealed on opposing sides to define gas flow passages between them. Adjacent passages are sealed at alternating sides of the carrier to establish the preliminary and secondary catalyst zones. In a plate-type carrier, the passages from the inlet faces to the outlet faces may provide a hydraulic diameter of from about 0.03 inches (0.76 mm) to 0.2 inches (5.1 mm).

In a typical embodiment, carrier 18 has a generally rectangular configuration, and the gas flow passages 24 are disposed in perpendicular crosswise relation to gas flow passages 26. Accordingly, the inlets and outlets of the first and second zones are disposed at different sides, i.e., distinct faces, of the carrier body. Accordingly, inlet 14 is dimensioned and configured to serve as a manifold that guides the gases to an entire face of carrier 18, i.e., inlet face 20. This feature of the present invention provides a distinction over prior art devices such as that shown in the Mieville et al Patent discussed above, in which the inlets of the first pass passages (124) of catalyst member (120) and the outlets of the second pass passages (124') are disposed on the same face of

member (120). Therefore, Mieville et al find it necessary to employ a special inlet manifold (118) to assure that gases entering the device flow only into passages (124), by masking all passages (124'). Since the zones in the carrier used with the present invention have inlets and outlets at distinct faces, there is no need for masking a manifold like the one in the Mieville et al Patent. Accordingly, the construction of device 10 is simpler than the construction of the Mieville et al device.

Device 10 further comprises a trap member 32 disposed within canister 12. Internal baffles 34 and 36 guide exhaust gases exiting the preliminary catalyst zone from first outlet face 22 towards trap member 32. Trap member 32 defines a plurality of gas flow passages 38 which extend from trap inlet face 40 to trap outlet face 42. Gas flow passages 38 comprise an adsorbent material effective to adsorb hydrocarbons in the exhaust gas stream at least during a cold-start period of engine operation. Since the present invention utilizes a heat exchange catalyst carrier, it is not necessary to employ a counterflow adsorbent carrier such as the one disclosed by Mieville et al. Accordingly, trap member 32 is a simple flow-through member that comprises only a single plurality of passages therethrough.

The adsorbent or "hydrocarbon trap" material may comprise any adsorptive material conventionally used to adsorb hydrocarbons, such as activated alumina, porous glass, silica gel and activated carbon. Natural and synthetic molecular sieves are particularly effective. Natural molecular sieves include faujasites, clinoptilolites, mordenites and chabazites. Zeolites, which comprise a class of molecular sieves which can be used, include silicalite, zeolite X, zeolite Y, ultrastable zeolite Y, ZSM-5, offretite and the like. Generally, sieve materials having so-called three-dimensional pore configurations are preferred over sieve materials having one- or two-dimensional pore configurations, although some of the latter function acceptably well. Zeolites, including

Beta-zeolite, are preferred materials. Typically, a Beta-zeolite hydrocarbon trap material is present on the carrier at a loading of about 0.5 to 3.0 g/in^3. Preferably, the zeolite material is a high silica material having a Si/Al ratio of at least about 100. For example, the Si/Al ratio may be from about 100 to 600. Preferably, the Si/Al ratio is greater than about 170. Trap member 32 may comprise a ceramic or metallic honeycomb substrate that defines gas flow passages 38 and onto which the adsorbent material is applied. In alternative embodiments, the trap member may comprise a porous bed of pellets of adsorbent material or a porous matrix comprising adsorbent material, or alternatively, trap member 32 may be formed by the extrusion of an adsorbent extrudate material.

Those skilled in the art will appreciate that whether a hydrocarbon trap material adsorbs or desorbs hydrocarbons from a gas stream depends on various factors such as the temperature of the trap material, the temperature of the gas stream, the concentration of hydrocarbons in the gas stream and the quantity of hydrocarbons already adsorbed on the trap material. It may therefore be misleading to say that the adsorption/desorption activity of the trap material depends solely on a single parameter such as trap material or gas stream temperature. However, for efficiency of expression, the transition between the conditions that determine whether the material will adsorb or desorb hydrocarbons is expressed herein and in the claims as a desorption temperature designated T_D, it being understood that this does not imply that temperature alone determines the performance of the trap material. Accordingly, when reference is made herein and in the claims to conditions "below temperature T_D", this indicates that the conditions favor net hydrocarbon adsorption by the trap material. Conversely, references to conditions "above temperature T_D" indicate conditions that favor net hydrocarbon desorption by the trap material.

Internal baffle 44 and the exterior wall of canister 12 define a gas flow path by which exhaust gases leaving

trap member 32 are guided towards second inlet face 28 of crossflow catalyst carrier 18. Internal baffles 34 and 44 define a gas flow path which guides exhaust gases from second outlet face 30 of carrier 18 to canister outlet 16.

In use, device 10 is placed in the exhaust gas line of an internal combustion engine. The exhaust gas enters canister 12 through inlet 14 and is guided to first inlet face 20, through which it enters the first catalyst zone defined by gas flow passages 24. Upon leaving the preliminary catalyst zone, the exhaust gas flows through trap member 32, and then re-enters carrier 18 through second inlet face 28. Upon leaving carrier 18 through second outlet face 30, the exhaust gas flows towards canister outlet 16. Thus, device 10 defines a gas flow path indicated by the gas flow arrows (unnumbered) therethrough in series through the preliminary catalyst zone, the trap means and then the secondary catalyst zone.

During the cold-start period of engine operation, the relatively cool exhaust gas contains substantial quantities of hydrocarbons, but due to its low temperature, the exhaust gas flows through the preliminary catalyst zone in carrier 18 substantially unaffected. The exhaust gas then flows through trap member 32, where the adsorbent material therein adsorbs substantial quantities of the hydrocarbons from the exhaust gas stream. The exhaust gas flows once again to carrier 18, this time through the secondary catalyst zone, and then exits the device.

As engine operation continues, the exhaust gas rises in temperature. By passing through carrier 18, the heat in the exhaust gas is readily transferred from the preliminary catalyst zone to the secondary catalyst zone. Thus, the exhaust gas entering trap member 32 is cooled relative to the exhaust gas entering canister 12 at inlet 14, at least for a short time following the cold-start period. By diverting heat away from trap member 32, desorption of hydrocarbons adsorbed therein during the cold-start period is delayed. In the meantime, the catalyst materials in the preliminary catalyst zone and the secondary catalyst

zone in carrier 18 approach or attain their light-off temperatures. Accordingly, as trap member 32 nears its desorption temperature, the catalyst material in the secondary catalyst zone is approaching its effective operating temperature, so when hydrocarbons begin desorbing from trap member 32, at least some are converted in the secondary catalyst zone to innocuous substances.

An alternative embodiment of an exhaust gas treatment device in accordance with the present invention is shown in Figures 1B and 1C, where device 10' comprises a canister 12' and has an inlet 14' and an outlet 16'. A heat exchange catalyst carrier 18' is mounted in canister 12', and is held in place by mounting brackets 46, which are sealed to the edges of carrier 18' and which serve to prevent gas by-pass around carrier 18'. Two trap members 32a' and 32b' are disposed within canister 12'. Device 10' also comprises an air inlet sparger 48 to allow the injection of oxygen, either as air or another oxygen-containing gas, into the exhaust gas stream at a point in the flow path between the first outlet face and the second inlet face of carrier 18'.

In use, exhaust gases are introduced into device 10' through inlet 14', enter a first manifold area 50 defined by canister 12' and mounting brackets 46, and is thus flowed into the preliminary catalyst zone of carrier 18'. After leaving the preliminary catalyst zone, the exhaust gas enters a second manifold area 52 and is flowed through a first trap member 32a'. The exhaust gas flows through a 180° turn in third manifold area 54 and then flows through a second trap member 32b'. After leaving second trap member 32b', the exhaust gas flows into a fourth manifold area 56 and then through the secondary catalyst zone of crossflow catalyst member 18', and enters fifth manifold area 58, from which the exhaust gas leaves the device through outlet 16'. While the exhaust gas is flowing therethrough, air or oxygen may be added thereto by means of sparger 48 to provide additional oxygen to facilitate combustion of hydrocarbons in the secondary catalyst zone.

In certain embodiments of the invention, one or both of the heat exchange catalyst carrier and the trap means may have a truncated configuration relative to the rectangular configuration shown, for example, in Figure 1B. The truncated configuration will accommodate a smaller canister design. Thus, the exhaust gas treatment devices of Figures 1D and 1E comprise plate-style heat exchange catalyst carriers 18a, 18b that resemble rectangular catalyst carriers having opposite corners truncated. The flow paths through such catalyst carriers are generally diagonal, and this increases the residence time of the gases flowing therethrough relative to a rectangular configuration in which each flow path extends straight across the carrier from one side to another. The increased residence time for the gas stream leads to greater heat exchange efficiency and prolonged exposure to the catalytic material therein. As a result of the diagonal flow of exhaust gases through the carrier, the flow paths through the primary and secondary catalyst zones are disposed in oblique crosswise relation to one another. In the embodiment of Figure 1D, the two passes of exhaust gas through carrier 18a flow in generally the same direction; this configuration is designated as a co-current flow configuration. A co-current flow configuration is believed to provide better heat exchange efficiency than the configuration of carrier 18b of Figure 1E, which is designated a counter-current flow configuration, through which two passes of exhaust gas flow in generally opposite directions. The counter-current flow configuration can sometimes yield better overall conversion performance.

The trap means may also be truncated or otherwise configured to conform to the flow path in the canister from the first outlet face to the second inlet face of the catalyst carrier. One way to design a trap means to conform to a particular flow path is to deposit the trap material on a series of plates, each of which is dimensioned and configured to conform to the flow path defined by the canister when disposed in parallel relation thereto. A plu-

rality of such plates may be disposed in spaced parallel relation to each other in the flow path so that the exhaust gas passes between the plates as it flows from the first outlet face to the second inlet face of the cross-flow carrier. Preferably, the plates are dimpled, corrugated or are otherwise configured to disrupt laminar flow of the gas flowing therebetween and to assure that a gas flow passage is maintained between adjacent plates.

In another aspect, the present invention provides an exhaust gas treatment device that contains a hydrocarbon trap means disposed between two catalyst zones which is adapted for the simultaneous treatment of two independent exhaust gas streams. Such a device can be used to treat the exhaust gas streams accumulated in the separate exhaust manifolds of an engine having cylinders disposed in a V-configuration without the need to first converge the exhaust gas streams. The invention thus provides that dual exhaust gas streams can be treated simultaneously in a single treatment apparatus, and therefore avoids the need to provide a conventional exhaust treatment system for each gas stream, or to combine the gas streams prior to treatment in a conventional treatment apparatus. Broadly described, this aspect of the invention provides an exhaust treatment apparatus having two preliminary catalyst zones and two secondary catalyst zones and a hydrocarbon trap between them. A preliminary catalyst zone, a trap member and a secondary catalyst zone is associated with each exhaust gas stream to be treated, and the preliminary catalyst zone for one gas stream is disposed in heat exchange relation with the secondary catalyst zone for the other exhaust gas stream. Conduit means, such as tubing or a canister and baffles, defines flow paths for each exhaust gas stream from the preliminary catalyst zone to the secondary catalyst zone, and a trap member is disposed in each flow path.

One embodiment of an exhaust gas treatment device in accordance with this second general aspect of the present invention is shown in Figures 2A and 2B, where device 110

is seen to comprise a canister 112 that has two inlets 114a and 114b, one for each exhaust gas stream A, B (indicated by arrows) to be treated. Device 110 further comprises a pair of heat exchange catalyst carriers 118a and 118b, a trap member 132a, 132b for each exhaust gas stream passing through device 110, and a pair of outlets 116a and 116b, one for each exhaust gas stream. Carriers 118a and 118b are substantially similar to those described in previous embodiments, i.e., they each comprise a preliminary catalyst zone and a secondary catalyst zone. However, as will be described below, the two catalyst zones of each crossflow catalyst carrier 118a and 118b treat different exhaust gas streams. Trap members 132a and 132b are similar to the trap members described in earlier embodiments.

In use, a first exhaust gas stream enters device 110 through inlet 114a, and flows through the preliminary catalyst zone of carrier 118a. The exhaust gas then flows through trap member 132a and then through the secondary catalyst zone of carrier 118b, from which it leaves device 110 through outlet 116a. A second exhaust gas stream enters device 110 through inlet 114b, simultaneously with the flow of the first exhaust gas stream just described. The second exhaust gas stream flows through the primary catalyst zone of crossflow carrier 118b in crossflow relation to the first exhaust gas stream flowing in the secondary catalyst zone of carrier 118b. The second exhaust gas stream then flows through trap member 132b, through the second catalyst zone of carrier 118a, in crossflow relation to the first gas stream flowing through the primary catalyst zone of carrier 118a, and then to outlet 116b. Thus, heat derived from the exhaust gas streams introduced into inlets 114a and 114b are transferred from the preliminary catalyst zones of carriers 118a and 118b to the secondary catalyst zones of 118a and 118b, where the other, separate exhaust gas stream is passing through the secondary catalyst zone of the respective carriers. Thus, the heat in each exhaust gas stream as it enters a preliminary catalyst zone is transferred to a secondary

catalyst zone, drawing heat away from trap members 132a and 132b to postpone the desorption of hydrocarbons, and also facilitating the treatment of hydrocarbons desorbed from trap members 132a and 132b in the secondary catalyst zones. Optional air or oxygen spargers 148a and 148b can be used to inject oxygen into the exhaust gas streams to facilitate the conversion of the hydrocarbons in the secondary catalyst zones and to cool the hydrocarbon traps.

While the invention has been described in detail with respect to specific preferred embodiments thereof, and while some features may be illustrated in connection with certain embodiments thereof and not with others, this should not be construed to be a limitation of the invention, and it is to be understood that upon a reading of the foregoing description, variations to the specific embodiments disclosed may occur to those skilled in the art and it is intended to include such variations within the scope of the appended claims.

THE CLAIMS

What is claimed is:

1. An exhaust gas stream treatment device comprising:

a canister defining a canister interior and having a canister inlet for receiving an exhaust gas stream into the canister and a canister outlet for discharging the exhaust gas stream from the canister;

a heat exchange catalyst carrier contained within the canister and having first and second carrier inlet faces and first and second carrier outlet faces, the inlet faces being distinct from the outlet faces, the carrier comprising first and second pluralities of gas flow passages defined by carrier walls on which are disposed respective catalytic materials, the first plurality of gas flow passages being open to and extending between the first inlet and outlet faces to define a preliminary catalyst zone, and the second plurality of gas flow passages being open to and extending between the second inlet and outlet faces to define a secondary catalyst zone, the first and second pluralities of gas flow passages being disposed in heat exchange relation with each other and defining separate gas flow paths through the carrier; and

trap means disposed within the canister, the trap means having a trap inlet face and a trap outlet face, being permeable to gas flow therethrough from the trap inlet face to the trap outlet face and comprising a material having a hydrocarbon desorption temperature ("T_D") and being suitable for adsorbing hydrocarbons in the exhaust gas stream exiting the preliminary catalyst zone while the stream is below temperature T_D, and for desorbing hydrocarbons while the stream is above temperature T_D;

wherein the catalyst carrier and the trap means are oriented with respect to each other, and the canister interior is dimensioned and configured to define a flow path from the canister inlet to the first carrier inlet

face, through the preliminary catalyst zone to the first carrier outlet face, then through the trap means and to the second carrier inlet face, through the secondary catalyst zone to the second carrier outlet face and then to the canister outlet.

2. The device of claim 1 wherein the canister interior is dimensioned and configured to provide a first gas flow conduit between the first carrier outlet face and the inlet face of the trap means, a second gas flow conduit between the outlet face of the trap means and the second carrier inlet face, and a gas flow discharge conduit connecting the second carrier outlet face with the canister outlet.

3. The device of claim 1 wherein the canister comprises an oxygen inlet means for allowing the injection of oxygen into the exhaust gas stream.

4. The device of claim 3 wherein the oxygen inlet means is positioned at a point in the flow path between the first carrier outlet face and the second carrier inlet face.

5. The device of claim 2 wherein the catalyst carrier is dimensioned and configured so that exhaust gas flows through the preliminary catalyst zone in oblique relation to the flow through the secondary catalyst zone.

6. A dual flow path exhaust treatment apparatus comprising:

a pair of heat exchange catalyst carriers, each carrier comprising first and second pluralities of gas flow passages therethrough, the gas flow passages being defined by carrier walls on which are disposed respective catalytic materials, the first plurality of passages in each carrier defining a preliminary catalyst zone and the second plurality of passages in each carrier defining a

secondary catalyst zone, the preliminary catalyst zone of each carrier being in heat exchange relation with the secondary catalyst zone in the carrier and defining separate gas flow paths through the respective carriers;

conduit means for defining flow paths from the preliminary catalyst zone of each carrier to the secondary catalyst zone of the other carrier; and

trap means disposed in each conduit means, each trap means having a trap inlet face and a trap outlet face being permeable to gas flow therethrough from the trap inlet face to the trap outlet face and comprising a material having a hydrocarbon desorption temperature ("T_D") and being suitable for adsorbing hydrocarbons in an exhaust gas stream while the gas stream is below temperature T_D and for desorbing hydrocarbons while the gas stream is above temperature T_D.

7. The exhaust treatment apparatus of claim 6 further comprising oxygen inlet means for allowing the injection of oxygen into the flow paths.

8. The exhaust treatment apparatus of claim 7 wherein the oxygen inlet means is positioned at a point in the flow path between the first outlet face of one carrier and the second inlet face of the other carrier.

9. The exhaust treatment apparatus of claim 7 wherein at least one of the preliminary catalyst zone and the secondary catalyst zone comprises a three-way catalyst material.

10. The exhaust treatment apparatus of claim 6 wherein the conduit means comprises a canister defining a canister interior and having first and second canister inlets, each for receiving an exhaust gas stream, and first and second canister outlets for discharging the exhaust gas streams from the canister, wherein the canister, the carriers and the trap means are oriented with respect to

each other, and the canister interior is dimensioned and configured to define two separate flow paths, each flow path extending from a canister inlet to the first inlet face of one carrier, from the first outlet face of the carriers to a trap means inlet face, from the trap means outlet face to the second inlet face of the other carrier, and from the second outlet face of said other carrier to a canister outlet.

11. The exhaust treatment apparatus of claim 10 wherein at least one of the carriers is dimensioned and configured so that exhaust gases flow through the preliminary catalyst zone in oblique relation to exhaust gas flowing through the secondary catalyst zone.

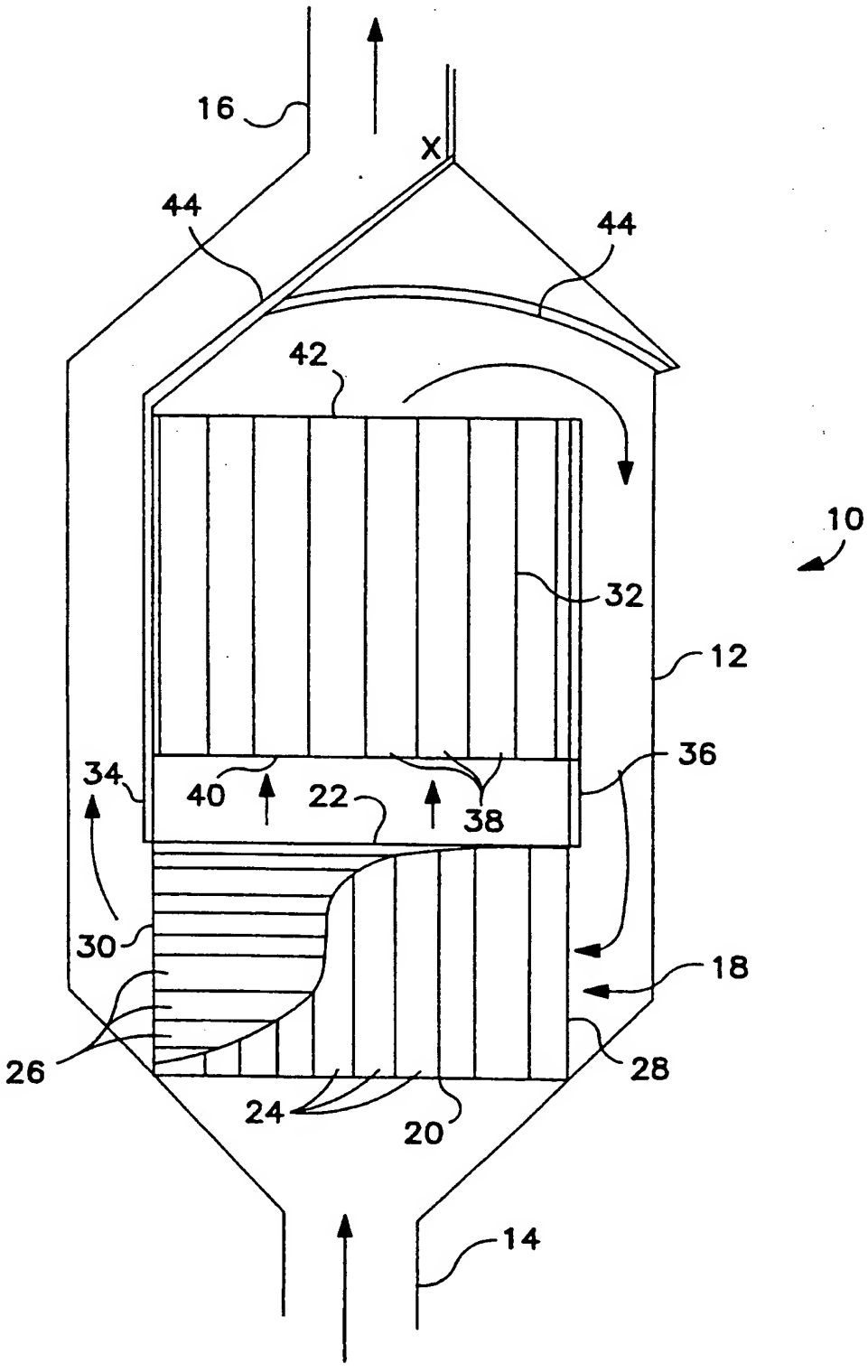
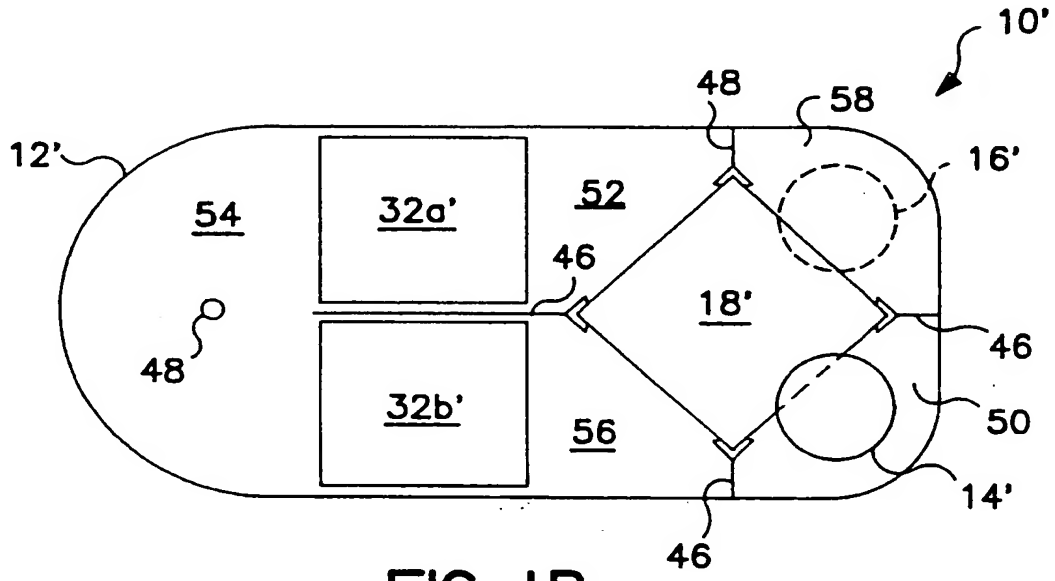


FIG. IA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12'
16'
54
32a'
52
46
18'
48
46
32b'
56
50
14'
46

FIG. 1B

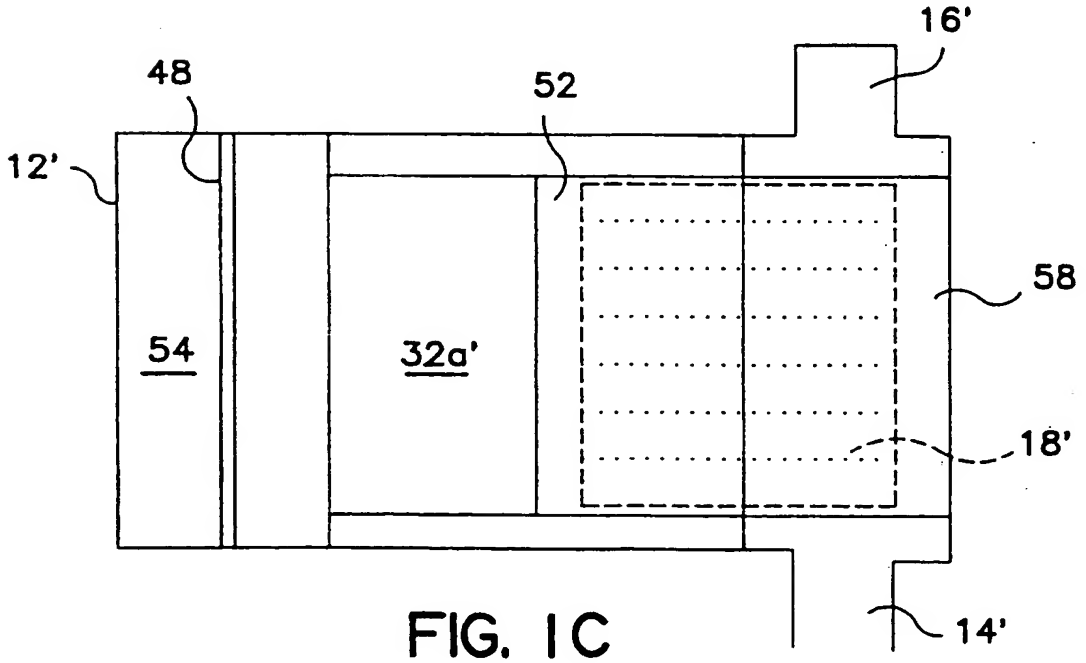
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FIG. 1C

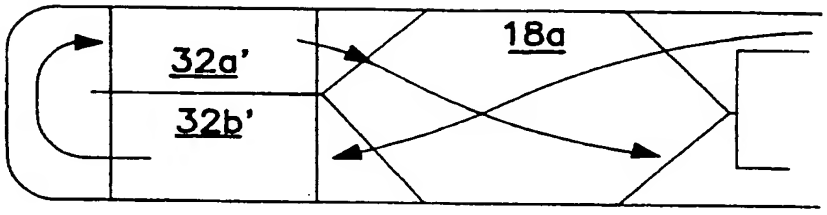


FIG. 1D

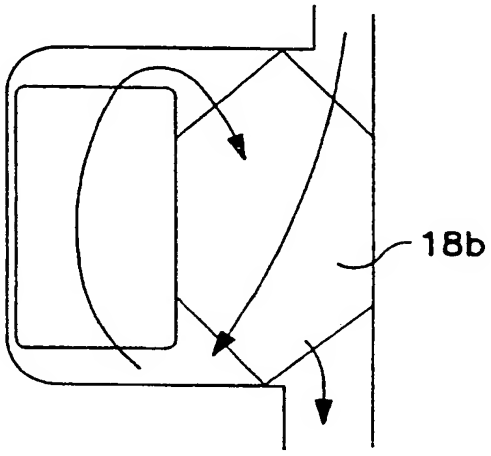
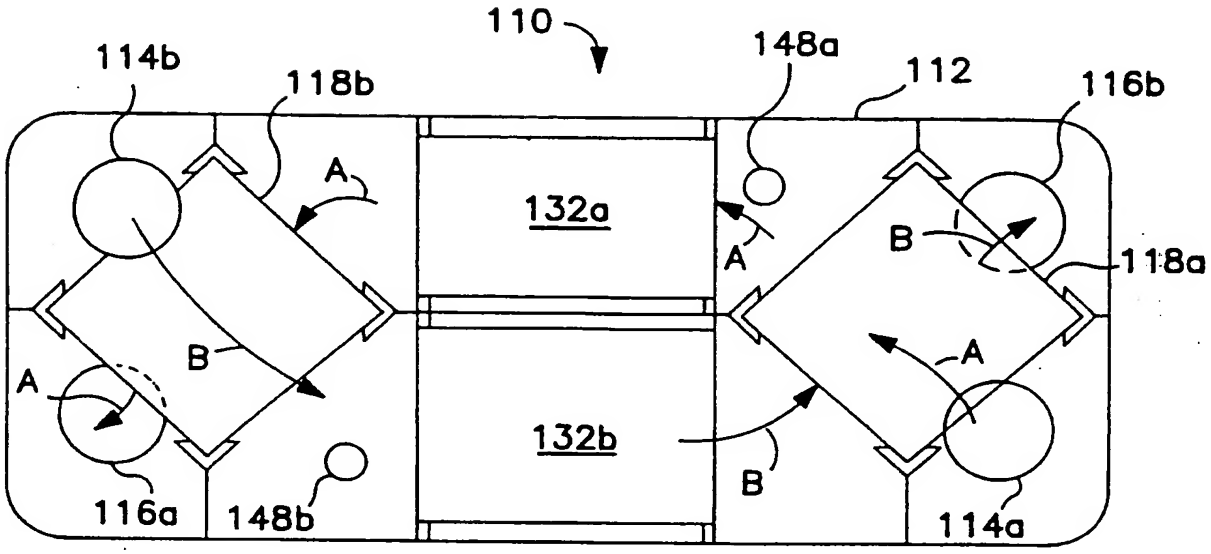


FIG. 1E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118a
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A
A
132b
B
116a
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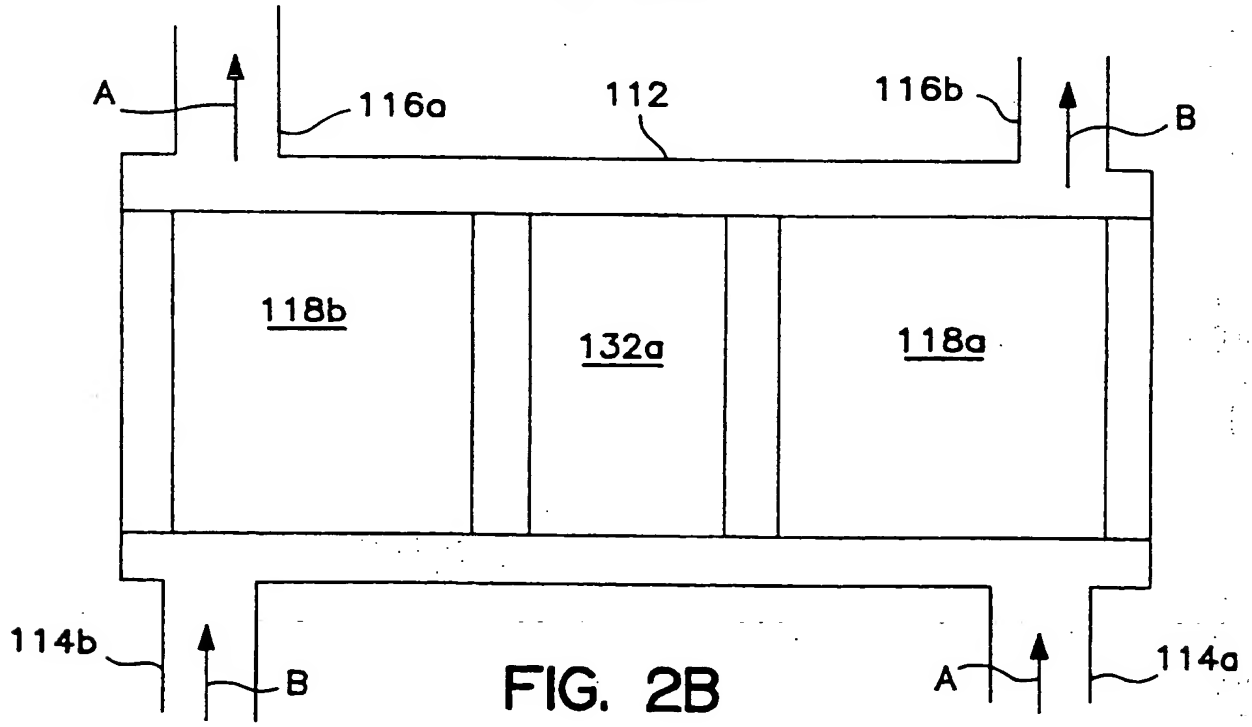
114a

FIG. 2A


A
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116b
B
118b
132a
118a
114b
B
A
114a

FIG. 2B

INTERNATIONAL SEARCH REPORT

Intern ıal Application No
PCT/US 95/14173

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F01N3/28 F01N3/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,5 303 547 (MIEVILLE) 19 April 1994 cited in the application see column 6, line 51 - column 7, line 37; figures 7-9 ---	1,6
A	DE,A,40 39 688 (NICHIAS CORP.) 27 June 1991 see column 4, line 4 - line 44; figure 2 ---	1,6
A	DE,A,29 42 359 (DAIKIN KOGYO) 26 June 1980 -----	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
28 February 1996	07. 03. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Friden, C

INTERNATIONAL SEARCH REPORT

...nformation on patent family members

Inter nal Application No
PCT/US 95/14173

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5303547	19-04-94	NONE	
DE-A-4039688	27-06-91	US-A- 5158753	27-10-92
DE-A-2942359	26-06-80	JP-A- 55056823	26-04-80